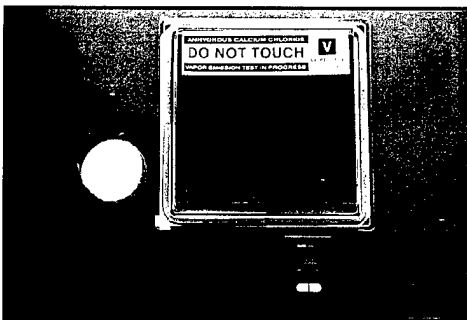
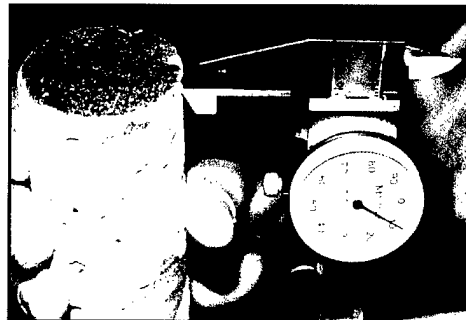
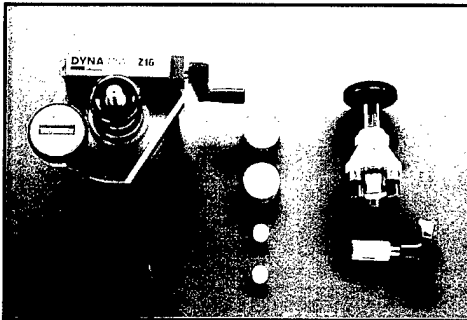




NAVAL FACILITIES ENGINEERING SERVICE CENTER
Port Hueneme, California 93043-4370

USER GUIDE UG-2038-SHR

CONCRETE FLOOR CONDITION ASSESSMENT



by

C. Dave Gaughen

November 1999

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EXECUTIVE SUMMARY

The Users Guide presents a systematic approach to assessing the condition of concrete floors prior to specifying one of three coating systems: A) Thin film coating system (≥ 13 mils: 1 mil = 0.001"), B) Thick film coating system (≥ 250 mils), and C) Overcoating sound coating systems (≥ 3 mils). By assessing the condition of concrete floor surfaces, coating failures resulting from the following practices should decrease: 1) Overcoating unsound coating systems, 2) Coating concrete with low surface strength, 3) Coating concrete with high levels of surface contamination (oils, fuels, skydrol, fats, waxes, etc.), and 4) Coating concrete with a high rate of moisture vapor emission.

Presented within the Users Guide are the following sections: 1) Condition assessment, and 2) Coating system requirements. The following tools and test kits are required to perform a complete concrete floor condition assessment: A) Measuring wheel, B) Portable adhesion tester, C) Concrete coring unit, and D) Three Moisture Vapor Emission Test Kits (MVETK). Enclosed in Appendix A is an example of a concrete floor repair and resurfacing map.

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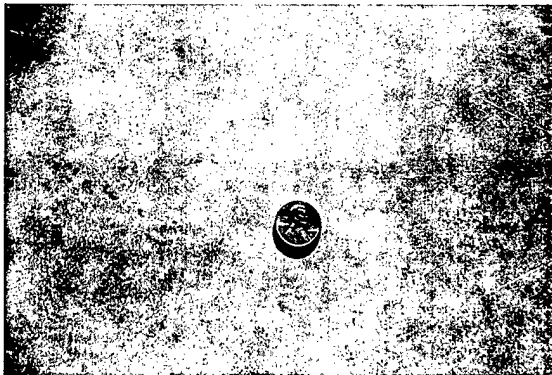
INTRODUCTION

The Users Guide presents a systematic approach to assessing the condition of concrete floors prior to specifying one of three coating systems: A) Thin film coating system (≥ 13 mils: 1 mil = 0.001"), B) Thick film coating system (≥ 250 mils), and C) Overcoating sound coating systems (≥ 3 mils). By assessing the condition of concrete floor surfaces, coating failures resulting from the following practices should decrease: 1) Overcoating unsound coating systems, 2) Coating concrete with low surface strength, 3) Coating concrete with high levels of surface contamination (oils, fuels, skydrol, fats, waxes, etc.), and 4) Coating concrete with a high rate of moisture vapor emission. Enclosed in Appendix A is an example of a concrete floor repair and resurfacing map. It is recommended that a map of the concrete floor be drawn and used to document cracks, spalls, coarse concrete, and popouts requiring either repair or resurfacing. A numbered legend corresponding to each area identified on the map is required to record the dimensions per repair and resurfacing area. Presented below are the following sections: 1) Condition assessment, and 2) Coating system requirements.

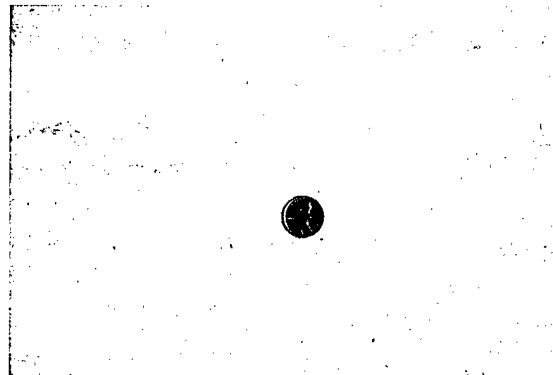
CONDITION ASSESSMENT

The following tools and test kits are required to perform a complete condition assessment: A) Measuring wheel, B) Portable adhesion tester, C) Concrete coring unit, and D) Three Moisture Vapor Emission Test Kits (MVETK).

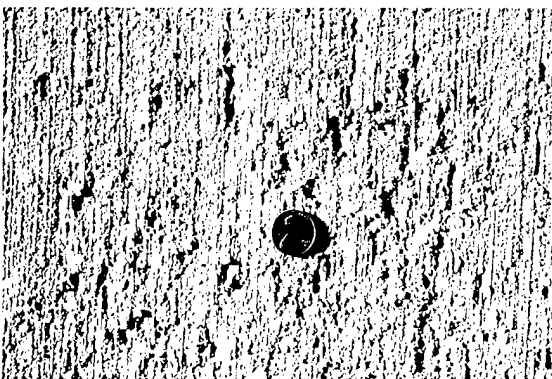
IDENTIFY CONCRETE SURFACE TEXTURE



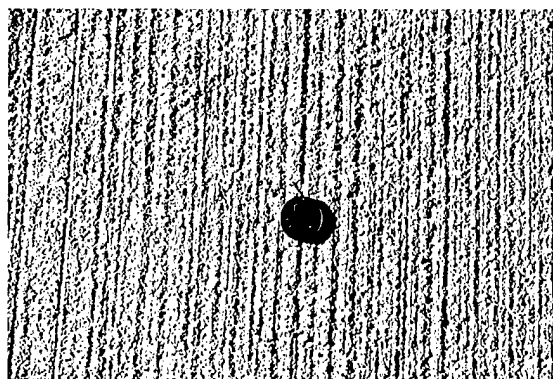
Steel trowel finish: "Smooth" surface texture.



Wood float finish: "Smooth" surface texture.



Wood float finish: "Coarse" surface texture.



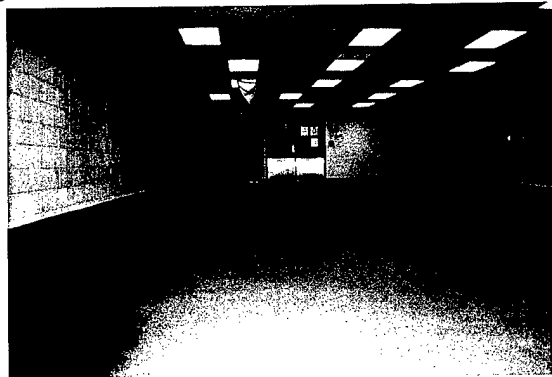
Broom finish: "Coarse" surface texture.

Identify and record the surface texture of the concrete as either "Smooth" or "Coarse". Surface textures greater than "Smooth" but less than "Coarse" shall be reported as "Coarse". If concrete is either coated or tiled, record surface as "Coated" or "Tiled."

MEASURE FLOOR DIMENSIONS



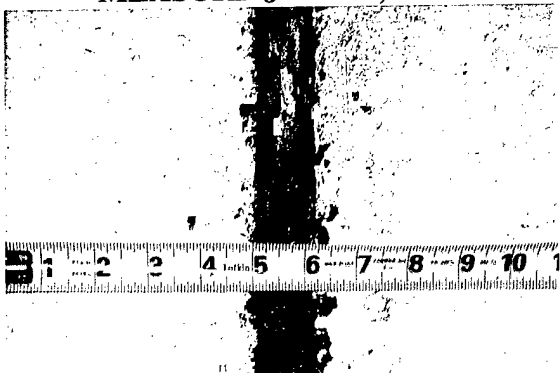
Measuring wheel.



Measure total area of floor surfaces.

Measure and record the interior area of all floor surfaces that are to receive coatings. Concrete floors generally receive coatings up to the base of interior perimeter walls. A measuring wheel is ideal for measuring the area of floor surfaces.

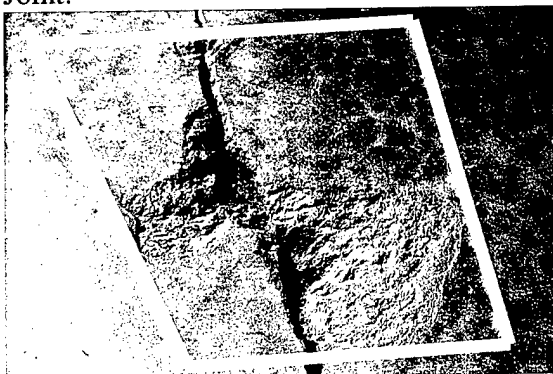
MEASURE JOINTS, CRACKS AND SPALLS



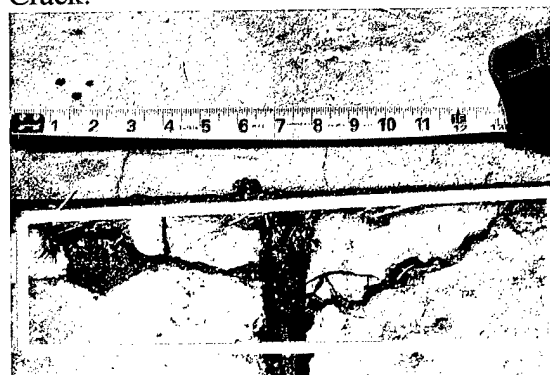
Joint.



Crack.



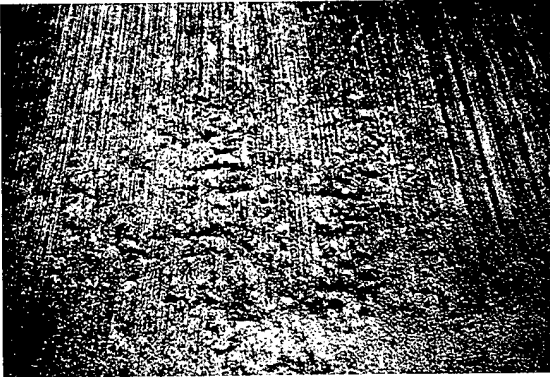
Crack spall with repair geometry.



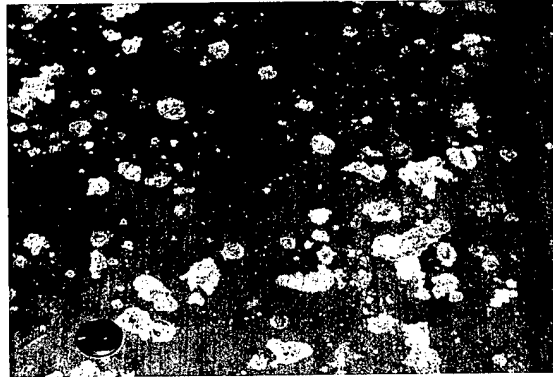
Corner spall with repair geometry.

Measure and record the total linear feet of joints and cracks classified by width. Cracks displaying widths less than 1/8" are not to be recorded. Measure the area of each spall in rectangular geometries as illustrated above. Record the total area of spalls.

MEASURE COARSE CONCRETE, POPOUTS AND FAILED COATINGS



Coarse concrete: Poor surface finishing.



Small popouts.



Failed coating system: "A".



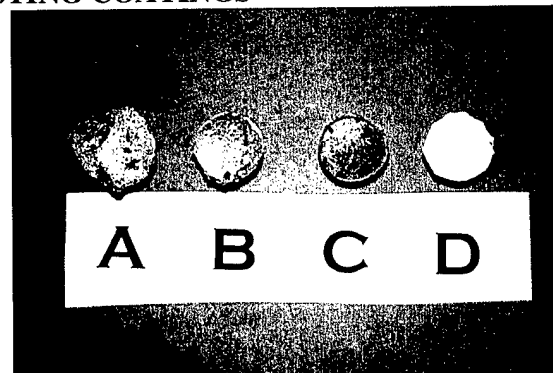
Spot failing of coating system: "B".

Measure and record the total area of concrete surfaces with surface textures greater than $\pm 1/4$ " (coarse concrete). Measure and record the total area of concrete with greater than $1/4$ " diameter popouts (small cone-shaped surface voids). Coating systems resembling "A" (above) shall be reported as a failed coating system whereas coating systems with spot failing resembling "B" (above) shall be measured and recorded. For coating systems with spot failing, use the measuring wheel to determine the total area of failed coatings. Individual coating failures less than 3" in diameter are not to be reported unless grouped together in visually significant densities.

DETERMINE ADHESION OF EXISTING COATINGS



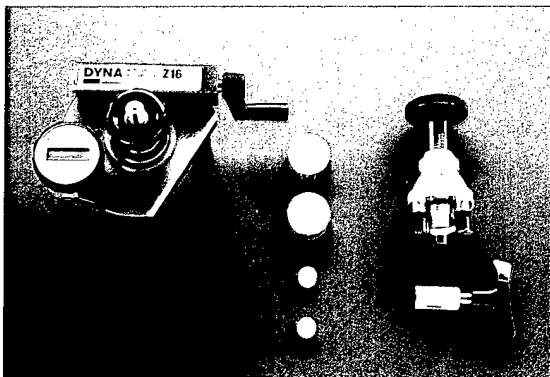
Elcometer™ portable adhesion tester with $3/4$ " pull-off coupon.



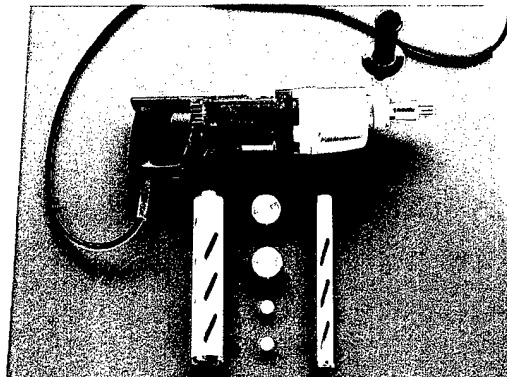
Resulting pull-off coupons. A-C, Cohesive failures (attached concrete); D, Adhesive failure (attached coating).

If less than 7 % of the floor surface contains coating failures, perform adhesion testing to determine the coating system's suitability for overcoating. Determine the adhesive strength of the existing coating system using a portable adhesion tester (ASTM-D-4541: American Society for Testing and Materials; West Conshohocken, PA). Perform nine adhesion tests per floor (3 left side, 3 center, 3 right side). Record adhesion values per test and document failure type (cohesive or adhesive: see above photograph).

DETERMINE CONCRETE SURFACE STRENGTH



Portable adhesion testers with pull-off coupons: Dyna tester (L) and Elcometer™ (R).



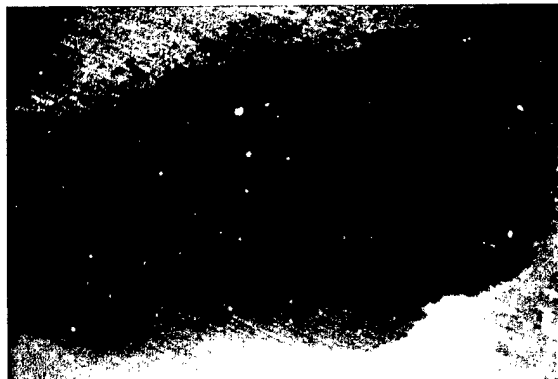
Portable core drill with air cooled core bits and pull-off coupons.

Determine the cohesive strength of the concrete's surface on uncoated floors, previously coated floors with a failed coating system, and tiled floors (ASTM-D-4541 or equivalent). On tiled surfaces, individual sections of tile and tile adhesive require removal. The tile adhesive may be removed using organic solvents (paint thinners) followed by scraping and scrubbing (the resulting surface is to appear visually clean and dry). Perform a minimum of three cohesive strength tests per floor (1 left side, 1 center, 1 right side) and record results. For concrete with aggregate larger than 3/8" diameter, adhesion testers employing 2" diameter pull-off coupons are preferred. The accuracy of cohesive strength testing may be improved by coring a distance of 1/8" to 3/8" into concrete surfaces prior to adhering pull-off coupons. If concrete cohesive values are low (≤ 200 psi), concrete surfaces may contain a weak layer of surface cement paste (laitance). Once the laitance is removed through a surface preparation technique such as shot blasting, cohesive strength values should increase. If cohesive failures are not produced within the concrete's surface (adhesive failures), concrete surfaces may contain surface contamination (fuels, oils, skydrol, fats, waxes, etc.) requiring degreasing prior to re-testing.

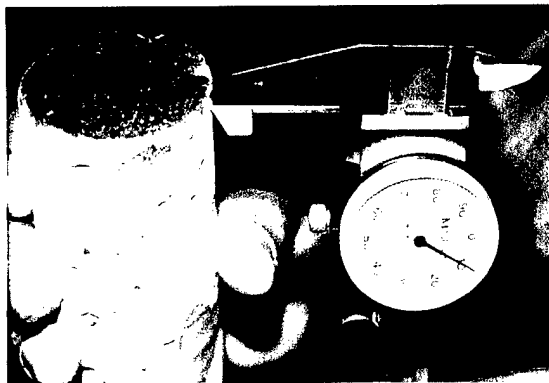
IDENTIFY CHEMICALS AND EXPOSURE

Identify and record each chemical used within the flooring space. Chemicals from the following chemical groups are to be documented by name and concentration: A) Acids, B) Bases (caustics), C) Organic solvents, D) Chlorinated solvents, E) Fuels, F) Oils, G) Degreasers, H) Detergents, I) Military specification solutions, J) Specialty chemicals, K) Plating baths, and L) Liquid gases. Determine the anticipated chemical exposure per chemical as either Occasional Spills (OS) or Daily Spills (DS). As a side note, a conductive coating system (reduces charges from static electricity) may be required in areas with electronic equipment, munitions, flammable liquids, and explosive gases.

DETERMINE DEPTH OF SURFACE CONTAMINATION



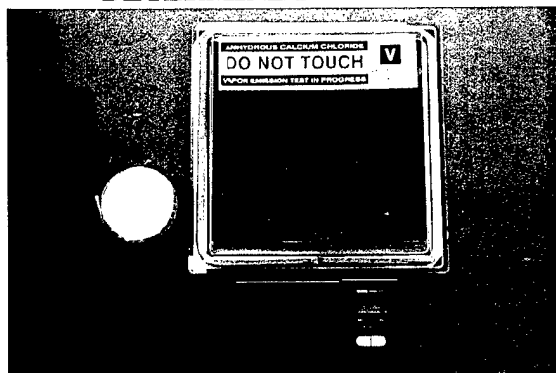
Oil saturated concrete.



Depth of surface contamination.

Determine the depth of surface contamination (oils, fuels, skydrol, fats, waxes, etc.) by extracting concrete cores preferably from uncoated and visually dirty surfaces (1 to 3 cores: 2"D x 3"L). If tiled, either remove individual sections of tile or core completely through tiled surfaces. On concrete cores with contamination a line can generally be seen which separates the dark-colored contamination from the uncontaminated concrete. Oils, fuels, fats, and waxes tend to be dark-colored whereas skydrol appears reddish. Measure and report the distance from the surface of each core to the end of the discoloration. Repair resulting core holes using a cementitious repair material.

DETERMINE RATE OF MOISTURE VAPOR EMISSION



Moisture Vapor Emission Test Kit (MVETK) with scale.



The MVETK is placed over concrete free of tile, tile adhesive, and coatings.

Determine the concrete's rate of moisture vapor emission by applying three Moisture Vapor Emission Test Kits (MVETK) per floor (right side, center, left side: ASTM-F-1869). Report the concrete's rate of moisture vapor emission as the average of the above three rates. When floor coatings are applied to concrete with a high rate of moisture vapor emission, vapor pressure sufficient to lift a coating system may be generated. MVETK contain calcium chloride (a common deicer) which absorbs water vapor at a linear rate. Each kit is applied directly to uncoated concrete for a continuous period of 60 to 72 hours. Prior to testing, coatings, tile, and tile adhesive require complete removal to bare concrete per test area (approximately 12 in² per test: see above photograph).

COATING SYSTEM REQUIREMENTS

If condition assessment results exceed the below coating system requirements, a Naval Facilities Coating Specialist is to be contacted prior to specifying a coating system.

THIN FILM COATING SYSTEM

A thin film coating system is for use on concrete floors with the following condition assessment results: 1) "Smooth" concrete surface texture, 2) Average moisture vapor emission rate ≤ 3.0 lbs/24 hours, 1000 ft², 3) Average concrete surface strength ≥ 200 psi, and 4) Average depth of surface contamination $\leq 1/4$ ". A thin film coating system may be applied to floors with a coarse surface texture, however the concrete's surface texture may mirror through the coating system to decrease aesthetics. Installation costs: \$3.00 - \$5.00 ft². Thickness: ≥ 13 mils. Approximate service life: *Overcoating at 4 years*. Benefits: *Low cost and average applicator skill*.

THICK FILM COATING SYSTEM

A thick film coating system is for use on concrete floors with the following condition assessment results: 1) Either "Smooth" or "Coarse" concrete surface textures, 2) Average moisture vapor emission rate ≤ 5.0 lbs/24 hours, 1000 ft², 3) Average concrete surface strength ≥ 200 psi, and 4) Average depth of surface contamination $\leq 1/4$ ". Installation costs: \$5.50 - \$10.00 ft². Thickness: ≥ 250 mils. Approximate service life: *Overcoating at 4 years*. Benefits: *Tolerates high moisture vapor emission rates, produces a level surface over coarse concrete, high impact resistance, and may provide a suitable topcoat base for ≥ 10 years service*.

OVERCOATING SOUND COATING SYSTEMS

Overcoating sound coating systems is to be used over either epoxy or urethane coating systems with the following condition assessment results: 1) Average moisture vapor emission rate ≤ 3.0 lbs/24 hours, 1000 ft², 2) Average coating system adhesive strength ≥ 250 psi or ≥ 200 psi with coating system producing cohesive failures within the concrete, and 3) Coating system failures total ≤ 7 % of floor surface. Installation costs: \$1.25 - \$3.00 ft². Thickness: ≥ 3 mils. Approximate service life: *At 4 years, either overcoating or complete coating system removal*. Benefits: *Increases service life of existing coating systems*.

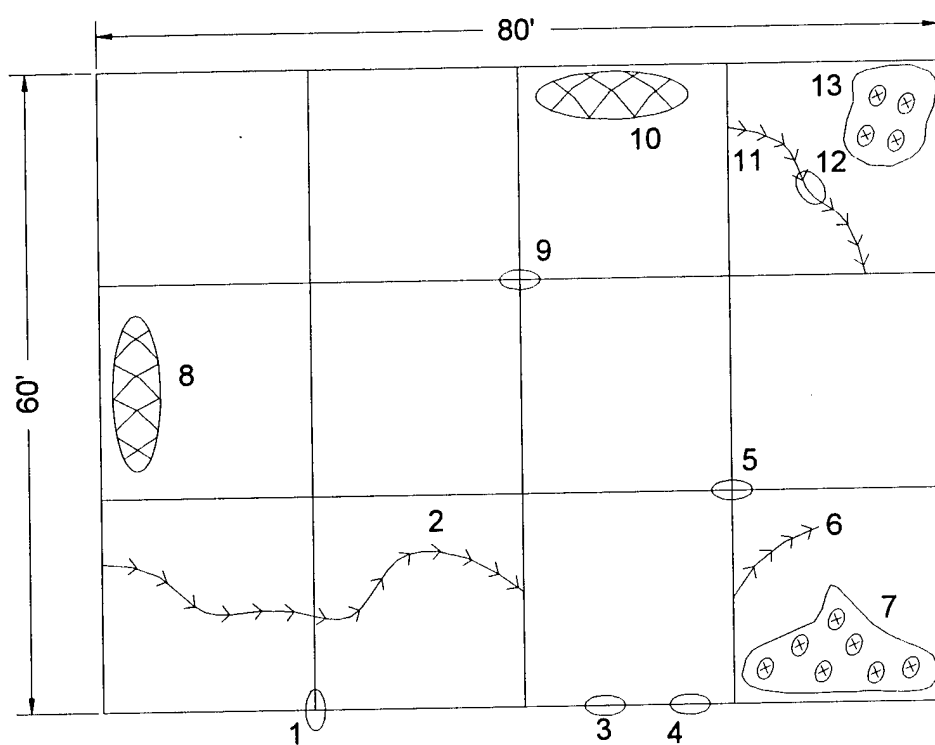
SUMMARIZE CONDITION ASSESSMENT RESULTS

Results from each condition assessment are to be summarized in the below format and placed within Section 1.1 titled "Background" of the appropriate coating specification. The completed "Repair and Resurfacing Map" with legend may be attached as an appendix for use with the coating specification. *"Building A contains 12,000 ft² of a failing coating system over concrete with a "Smooth" surface texture. The floor slab has 1080 ft of 1/4" joints, 100 ft of 3/4" joints, 127 ft of cracks up to 3/4" (width), and 50 ft² of spalled concrete. Greater than 12 % of the coating system has spot failed. The coating system has an average adhesive strength of 250 psi whereas the concrete's surface has an average cohesive strength of 275 psi. Oil contamination has penetrated the concrete's surface to an average depth of 1/8" (average of three cores). Results from moisture vapor emission testing indicate an average moisture vapor emission rate of 2.0 pounds moisture/24 hours, 1000 ft² (average of 3 tests). The following chemicals are used within the flooring space: A) JP - 8 (Daily Spills: DS), B) Skydrol (Occasional Spills: OS), C) Antifreeze (DS), D) Ethanol (DS), E) Isopropyl Alcohol (DS), F) 10 % Acetone (OS), G) 50 % Sodium Hydroxide (OS), H) 25 % Nitric Acid (OS), and I) 1 % Bleach (DS). Appendix A contains a "Repair and Resurfacing Map" with legend documenting the location and size of areas identified for either repair or resurfacing."*

APPENDIX A

REPAIR AND RESURFACING MAP

REPAIR AND RESURFACING MAP



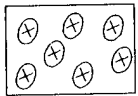
JOINTS



CRACK



SPALL



POPOUTS



COARSE SURFACE

The above symbols may be used to produce a map identifying floor surfaces requiring either repair or resurfacing. A number legend, corresponding to each area identified on the map, may be used to list the dimensions per repair and resurfacing area. The above symbols have been slightly modified from their original form presented in the "Distress Identification Manual for the Long-Term Pavement Performance Project" (Strategic Highway Research Program: SHRP-P-338).